QoS Provision for Mobile Access via GPRS

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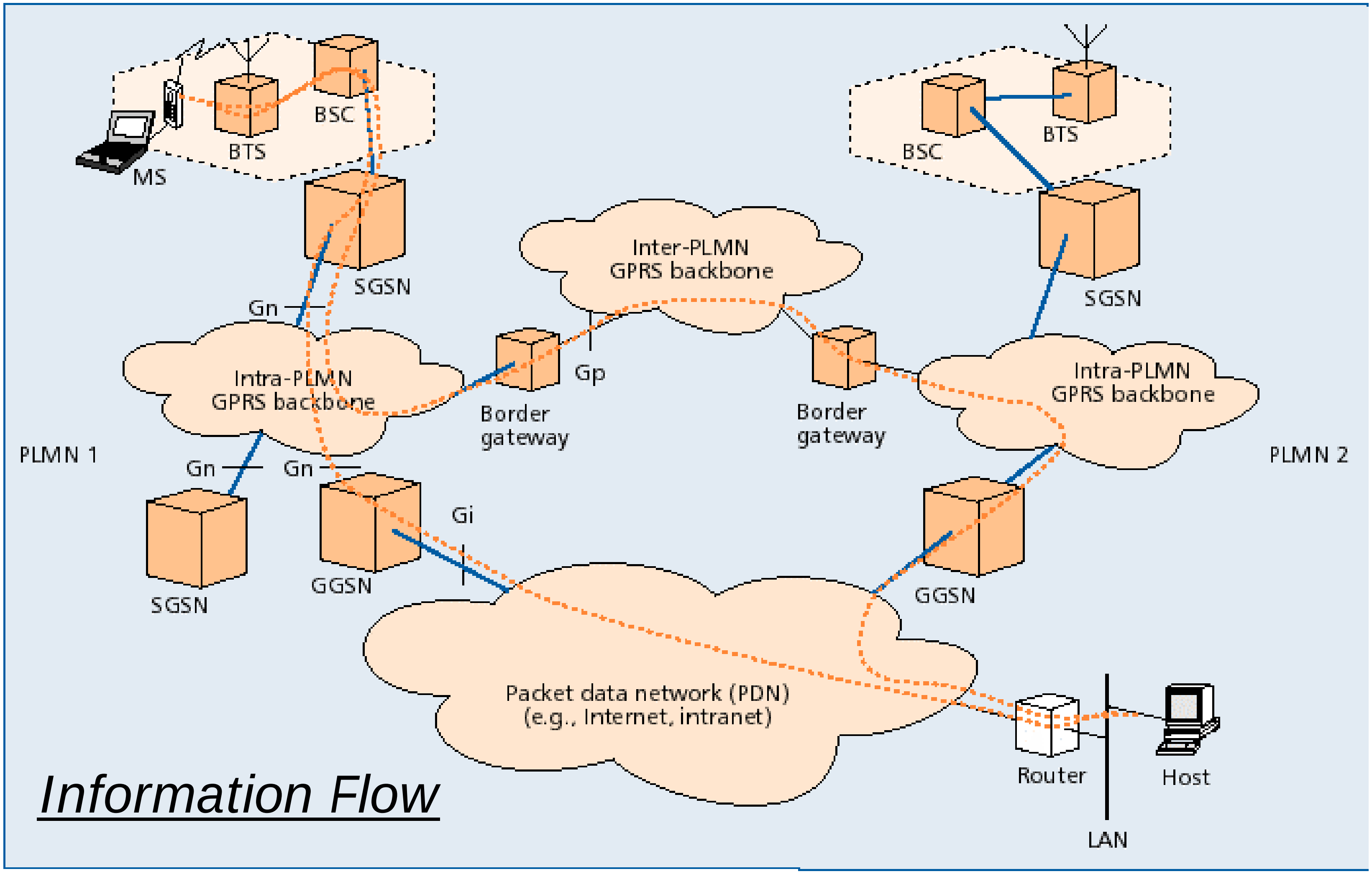
Overview

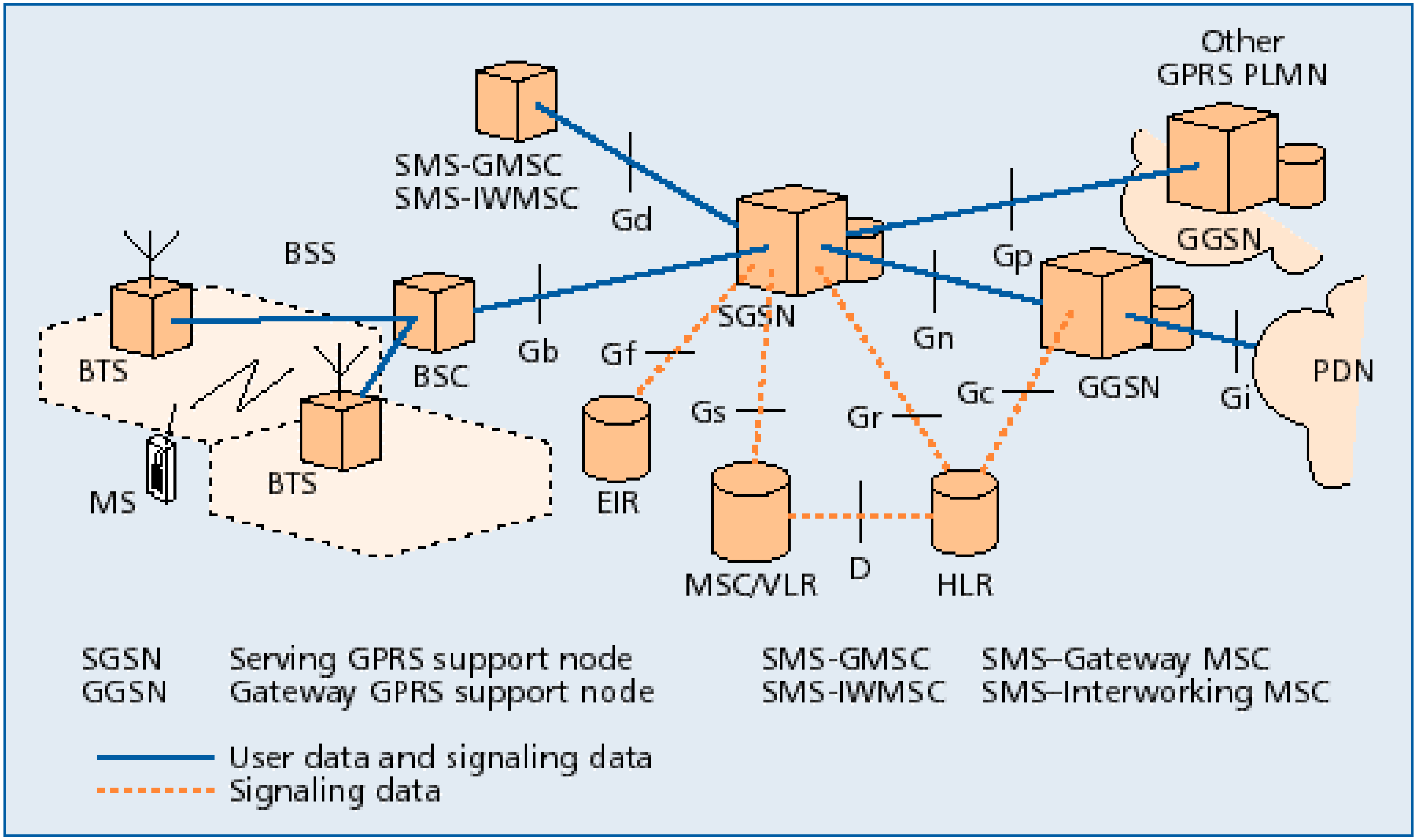
- Introduction to GPRS
- QoS provision
  - Purpose
  - Approach
- SSF simulation platform
- Implementation
- Simulation results
- Next Steps

Introduction to GPRS:

GPRS is GSM's extension for packet oriented data transmission.



GPRS architecture

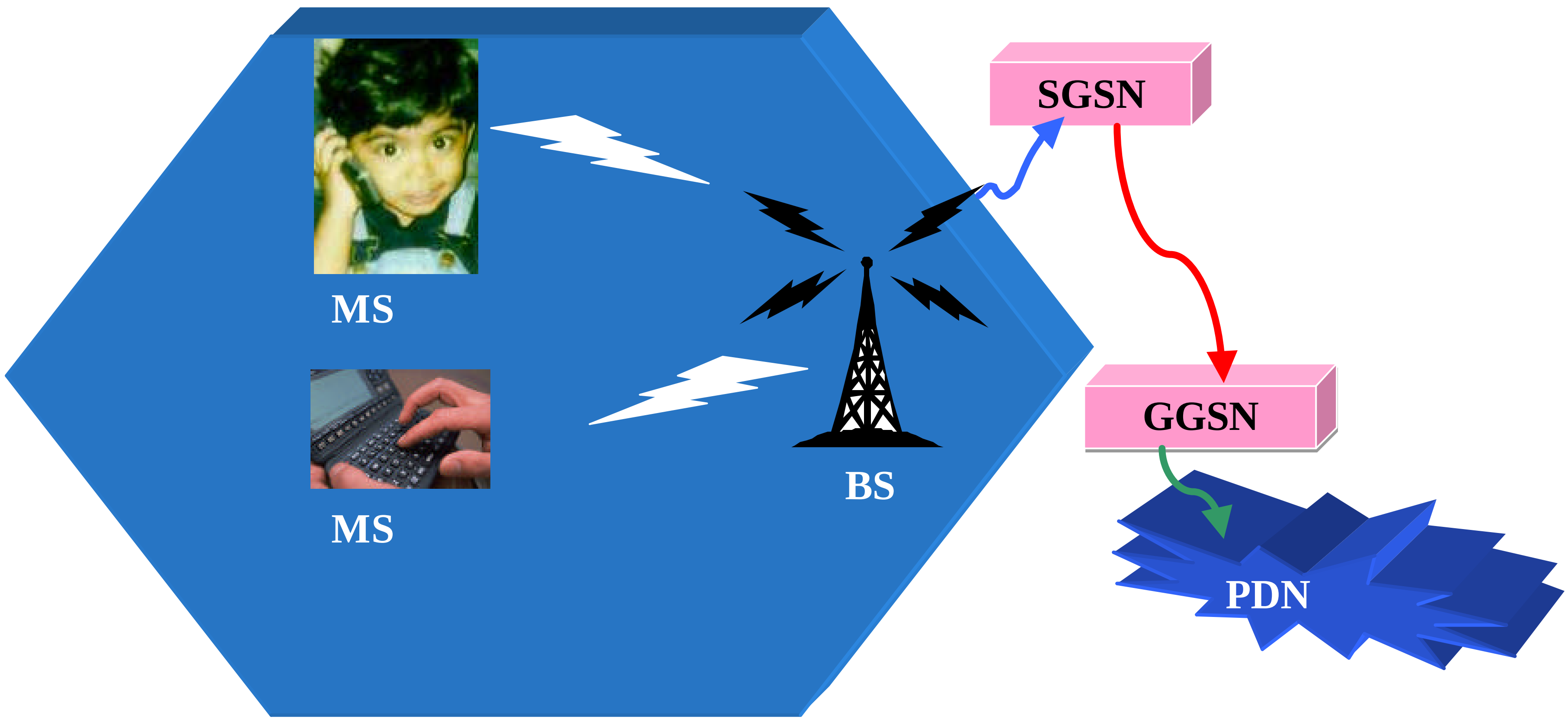


QoS Provisioning in GPRS

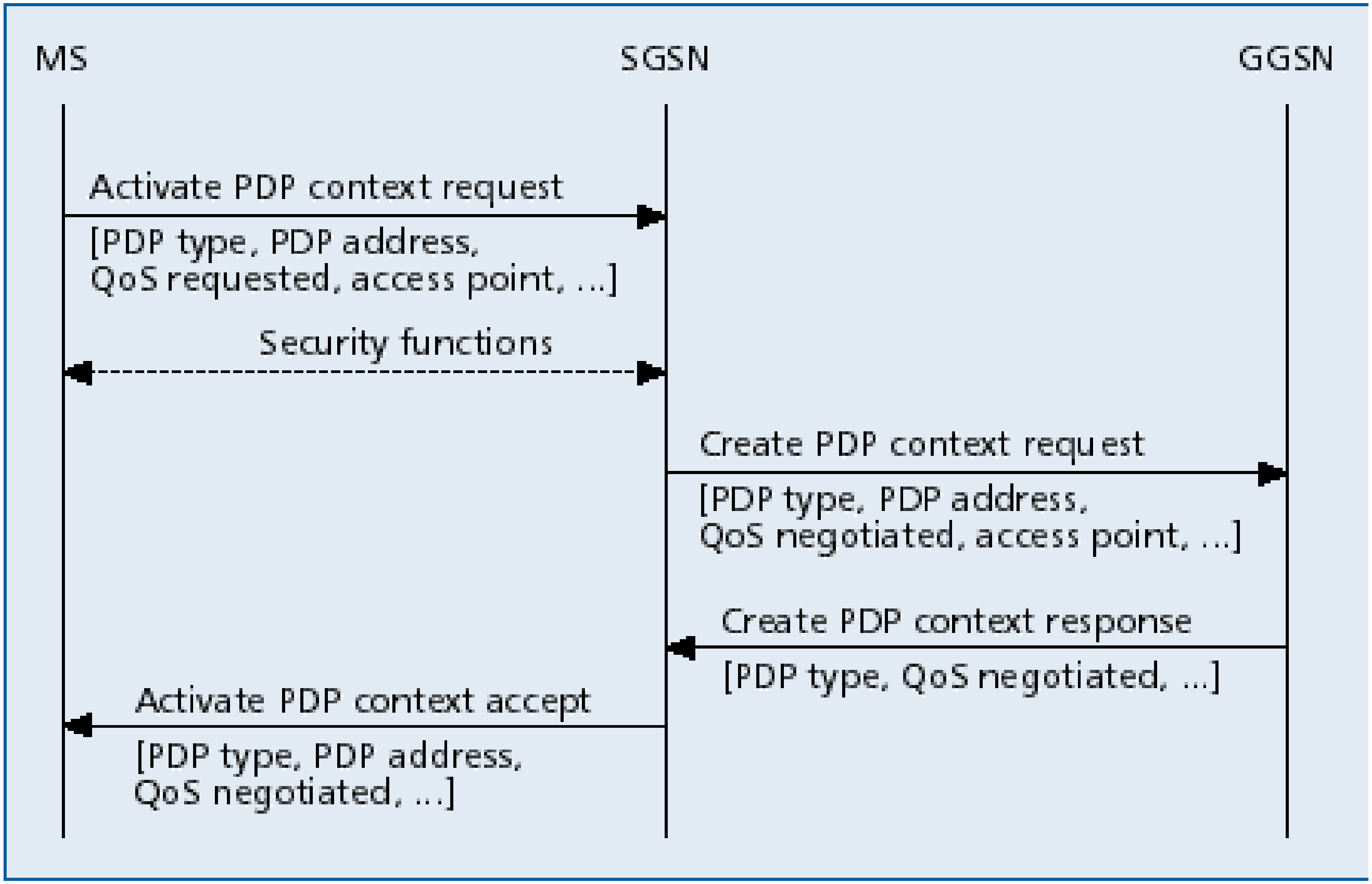
Purpose

- Multimedia applications need a wide range of QoS to be supported by the GPRS network.
- Adaptation and control strategies to ensure QoS have not been defined in GPRS.
- Aims to look at call admission and link adaptation schemes for both real time/non real time traffic in GPRS.

Where does QoS come into the picture?



QoS negotiations occur at the time of PDP (Packet Data Protocol) context activation/modification



QoS metric/ profile:

As per GSM 3.60, the QoS profile consists of the following parameters:

1. service precedence (priority)
2. reliability
3. delay
4. user data throughput
   - peak
   - mean

QoS profile

- **Service precedence (priority)**
  - Indicates the relative priority of maintaining the service.
    - High priority (class 1): Service commitments will be maintained ahead of all other precedence levels.
    - Normal priority (class 2)
    - Low priority (class 3)

Reliability

The reliability class defines probability of data loss, data delivered out of sequence, duplicate data delivery and corrupted data.

Reliability Class	GTP Mode	LLC Frame Mode	LLC Data Protection	RLC Block Mode	Traffic Type	
1	Acknowledged	Acknowledged	Protected	Acknowledged	Non real-time traffic, error-sensitive application that cannot cope with data loss.	**Nrt**
2	Unacknowledged	Acknowledged	Protected	Acknowledged	Non real-time traffic, error-sensitive application that can cope with infrequent data loss.	**Nrt**
3	Unacknowledged	Unacknowledged	Protected	Acknowledged	Non real-time traffic, error-sensitive application that can cope with data loss, GMM/SM, and SMS.	**Nrt**
4	Unacknowledged	Unacknowledged	Protected	Unacknowledged	Real-time traffic, error-sensitive application that can cope with data loss.	**Rt**
5	Unacknowledged	Unacknowledged	Unprotected	Unacknowledged	Real-time traffic, error non-sensitive application that can cope with data loss.	**Rt**
NOTE: For real-time traffic, the QoS profile also requires appropriate settings for delay and throughput.						

Delay

- Defines the maximum values for the mean delay and 95- percentile delay.
- This includes the radio channel access delay, radio channel scheduling delay, the radio channel and GPRS network transit delay.

Delay Class	Delay (maximum values)				
	SDU size: 128 octets		SDU size: 1024 octets		
	Mean Transfer Delay (sec)	95 percentile Delay (sec)	Mean Transfer Delay (sec)	95 percentile Delay (sec)	
1. (Predictive)	< 0.5	< 1.5	< 2	< 7	RT
2. (Predictive)	< 5	< 25	< 15	< 75	NRT
3. (Predictive)	< 50	< 250	< 75	< 375	NRT
4. (Best Effort)	Unspecified				NRT

Throughput

- Indicates the user data throughput requested by the user.
- Defined by two negotiable parameters:
  - Peak
  - Mean
- Various classes defined according to peak and mean throughput requirements.

Approach

- Intends to see how QoS can be delivered for different traffic types through:
  - call admission and control.
  - radio resource management.
  - link adaptation (changing code rate according to the current C/I).
- Provide QoS by abstracting the functionalities from LLC, RLC, MAC and BSSGP protocols.

UMTS traffic classes

	Conversational (delay <<1 sec)	Interactive (delay approx 1 sec)	Streaming (delay <10 sec)	Background (delay >10 sec)
Error tolerant	Conversational voice and video	Voice messaging	Streaming audio and video	Fax
Error intolerant	Telnet, interactive games	E-commerce, WWW browsing,	FTP, still image, paging	E-mail arrival notification

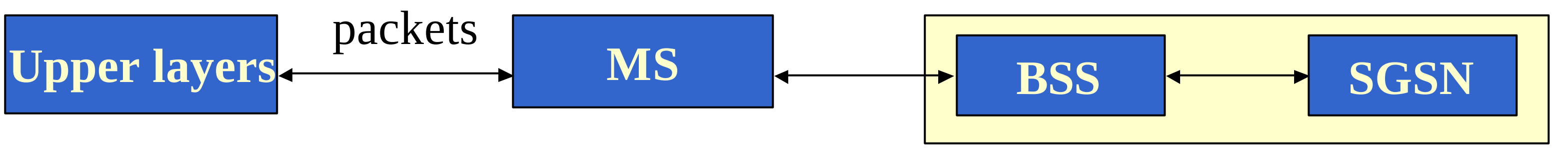
Approach

- "All bits are not created equal!"
- Have two main traffic classes in GPRS:
  - GPRS Conversational class/real time (rt)
    - have absolute QoS requirements.
    - if the negotiated QoS cannot be met, the MS is rejected
  - GPRS non-conversational class/non real time(nrt)
    - PDF (Packet data flows) adjust to the available bandwidth.
    - the relative QoS between different PDFs is kept.

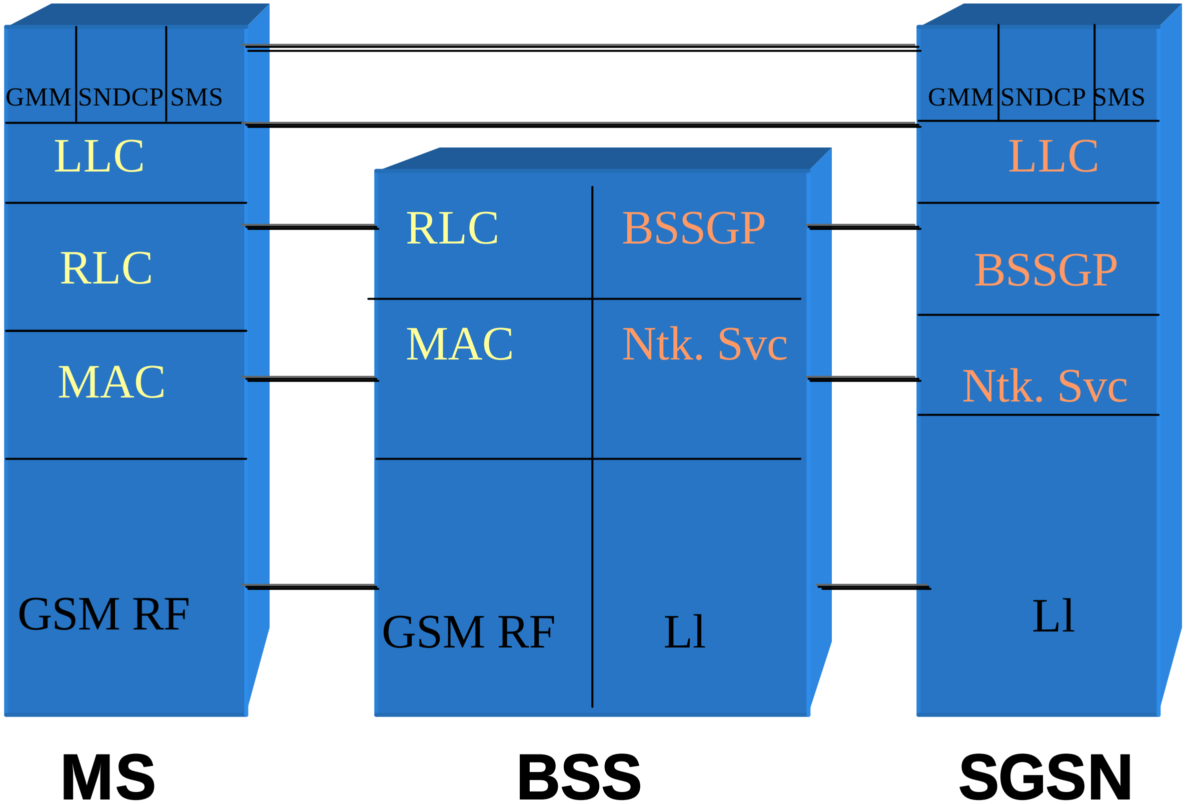
Approach

- **Call Admission and Control (CAC)**
  - CAC criteria
    - RT: check bandwidth requirement and also available bandwidth
    - NRT: check nrt queue and buffers available.
  - Maintain separate queues for rt and nrt packets.
  - Schedule packets on the basis of priority and delay class.
- **QoS profile in the BSS**

Simulation: Top Level



Transmission Plane Implementation



Simulation Platform:JSSF

(JAVA SCALABLE SIMULATION FRAMEWORK)

- SSF provides a single, unified interface for discrete-event simulation.
- Makes it possible to build models that are
  - Efficient
  - Scalable
  - able to utilize parallel processor resources.
  - Object-oriented
    - utilize and extend the framework
    - maximize the potential for direct reuse of code

SSF Syntax

- The SSF syntax comprises five base class interfaces:
  - Entity : Object that can **own** processes and channel endpoints, and can be aligned with other Entities
  - Event : sent on channels to processes in Entities
  - Process : sends events on outChannels.
  - inChannel : pipe leading to a process carrying events
  - outChannel : pipe going out from a process carrying events

Scope of the simulator

Simulation scenario currently restricted to:

- one GSM carrier
- one cell
- One BSS incorporating functionalities of BS and SGSN
- use of all coding schemes
- mean C/I can be varied as also variance
- concentrates on uplink performance
- User can specify the number of MS

Scope of the simulator

- Traffic Models:
  - Mobitex (mean packet length 30 bytes)
  - Exponentially distributed packets (mean 200 bytes)
- Channel Model
  - TU3
- RT and NRT packet separation
  - Delay class and priority based selection at the BS
  - RT packets are unacknowledged (no retransmissions)
  - NRT packets are acknowledged (selective ARQ)

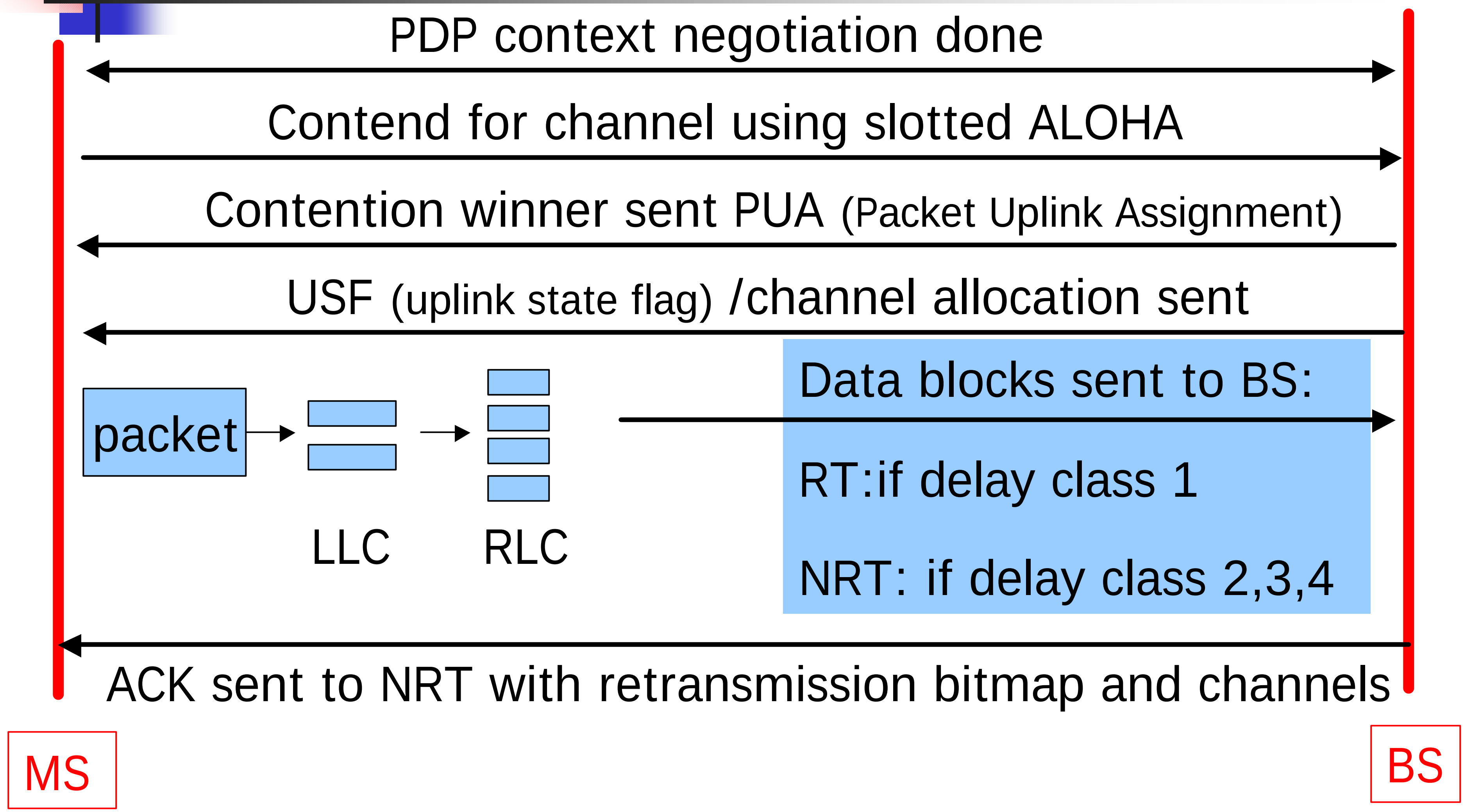
Implementation:

- **Physical Layer**:
  - C/I value is generated from a lognormal distribution with user specified parameters.
  - Emulated with a set of graphs of the BLER vs. C/I for the 4 channel coding schemes
  - As per BLER, RLC block is dropped/transmitted.
- **LLC**
  - sole functionality is the segmentation and reassembly of the LLC frames.

Implementation:

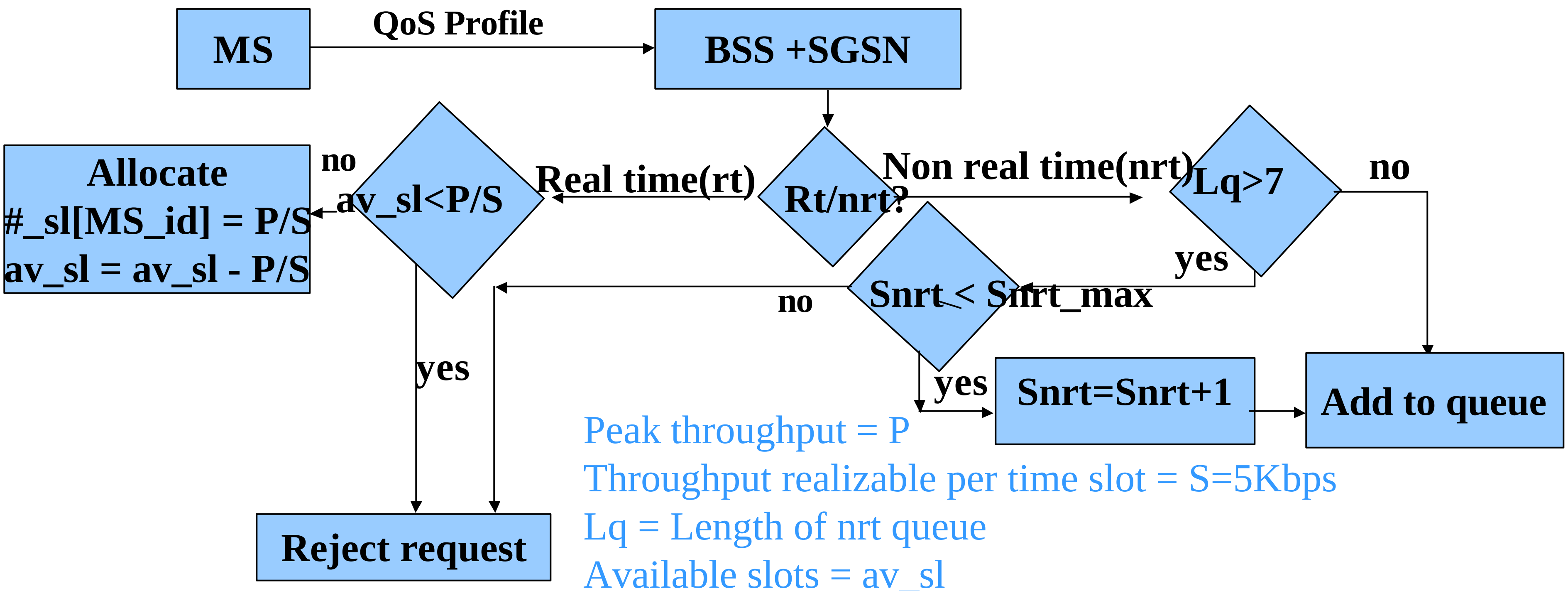
- **RLC**:
  - Acknowledged/Unacknowledged data transfer mode
  - BEC with sliding window ARQ mechanism
  - All four coding schemes are supported
- **MAC**:
  - Uses slotted ALOHA model
  - Includes capture model
  - Channel assignment by the BSS
  - Logical channels are implemented

Uplink Model Description



Algorithm for Resource allocation
(PDP negotiation)

Initially say out of the 7TS, one is allocated for nrt(on which 7 users can be mux.) and 6 TS are allocated for rt users.



Peak throughput = P

Throughput realizable per time slot = S=5Kbps

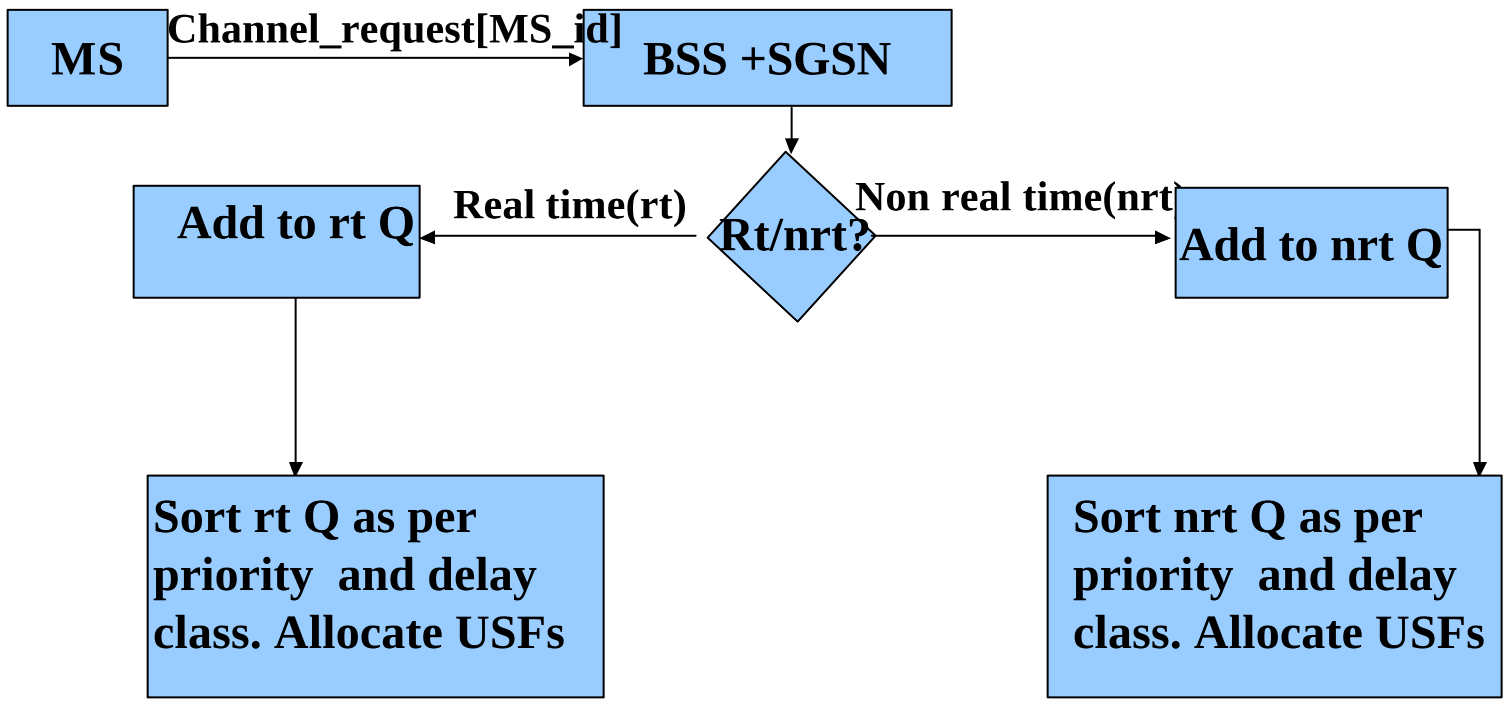
Lq = Length of nrt queue

Available slots = av_sl

Slots for nrt = Snrt

Max. # of slots for nrt = Snrt_max

Algorithm for Resource allocation
(Channel request)



GPRS CODING SCHEMES

Scheme	Code Rate	Payload (bits/block)	Data rate (Kb/s)
CS 1	1/2	181	9.05
CS 2	2/3	268	13.4
CS 3	3/4	312	15.6
CS 4	1	428	21.4

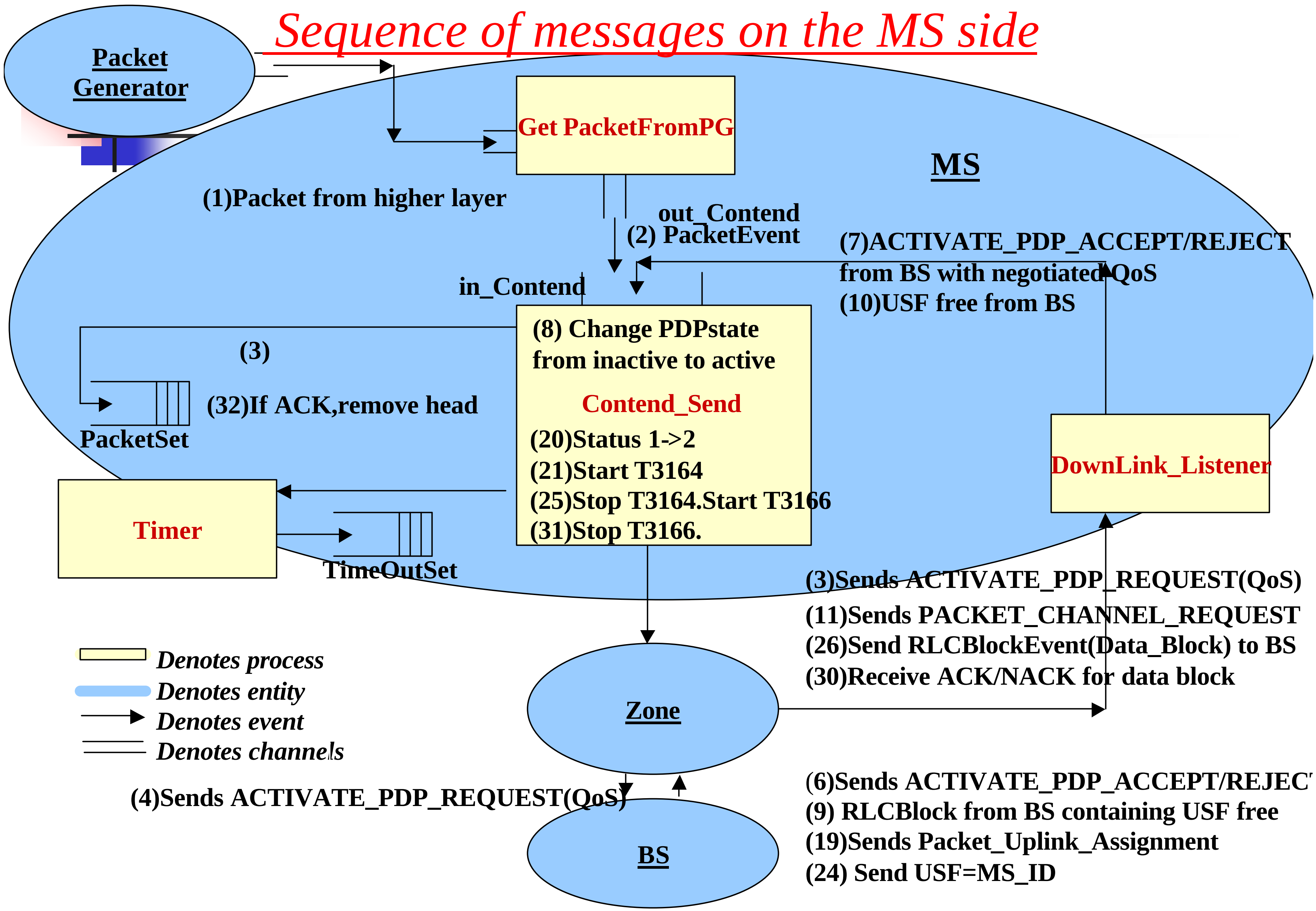
Optimizing Channel Capacity

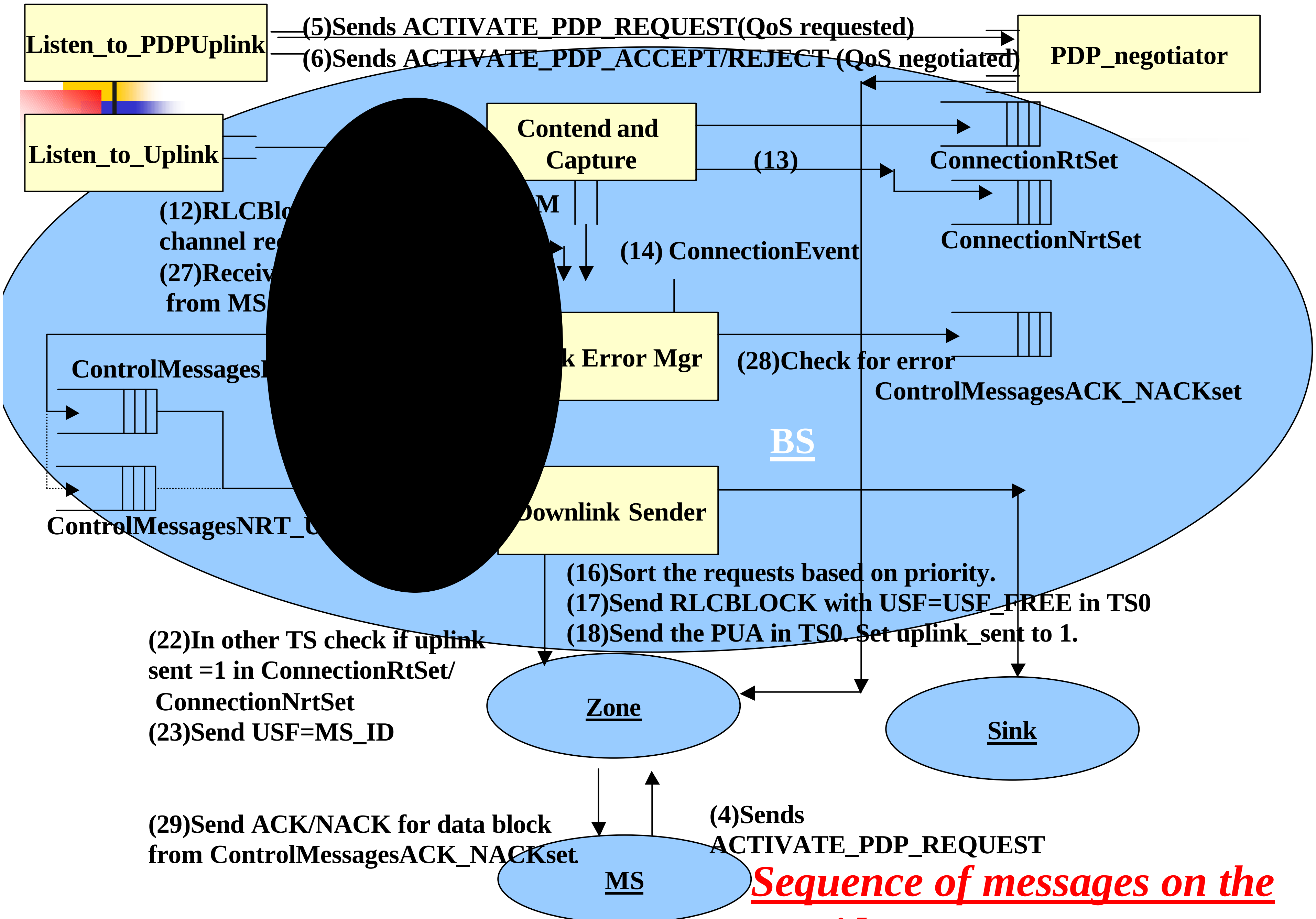
Link Adaptation:

Use higher coding schemes (less coding, more payload) when the radio conditions are good:

- RT packets : use CS3
- NRT packets:
  - use CS1 at C/I <10dB
  - use CS3 at 10<C/I <18dB
  - use CS4 at C/I >=18dB

Sequence of messages on the MS side

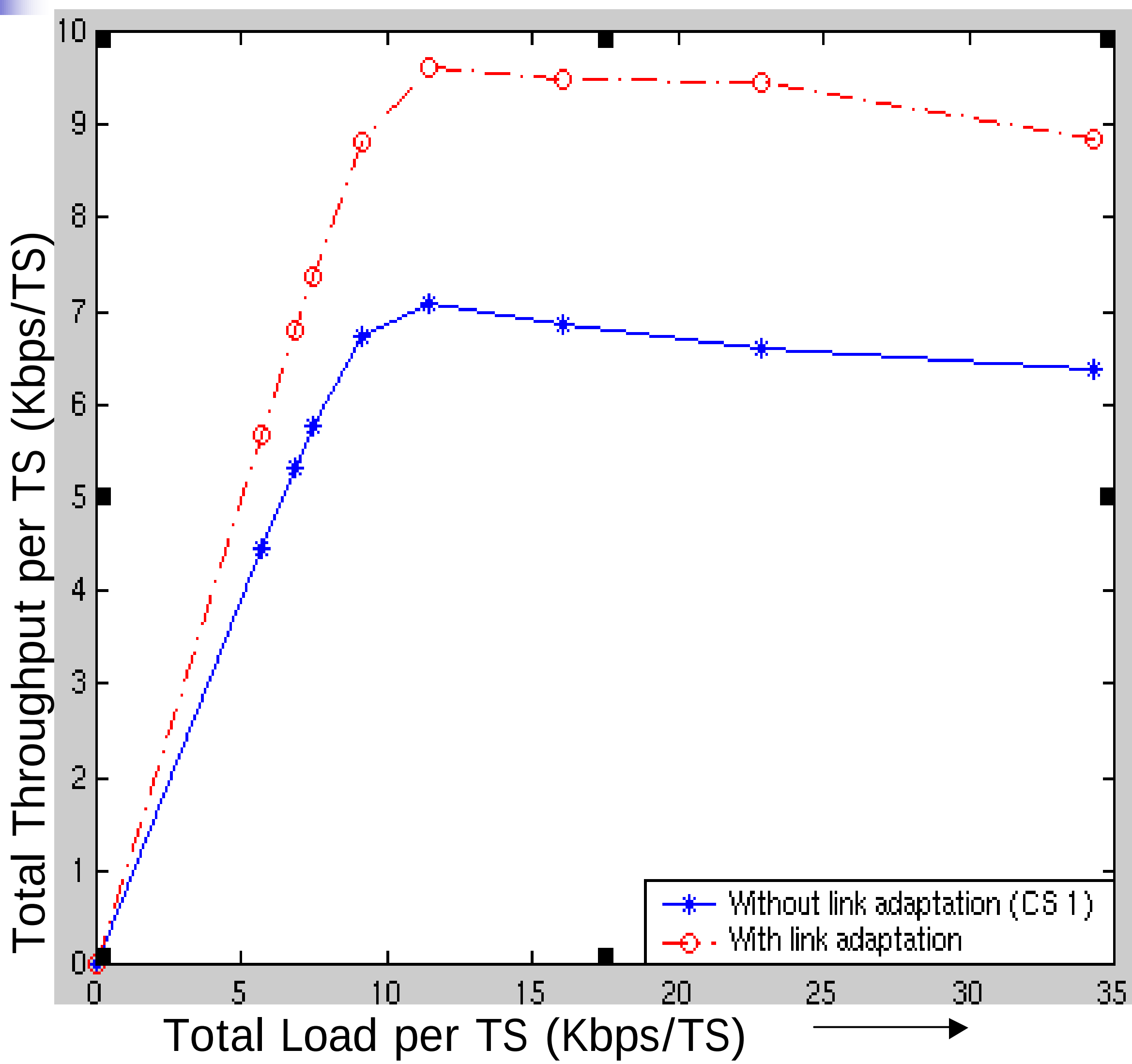




Sequence of messages on the BS side

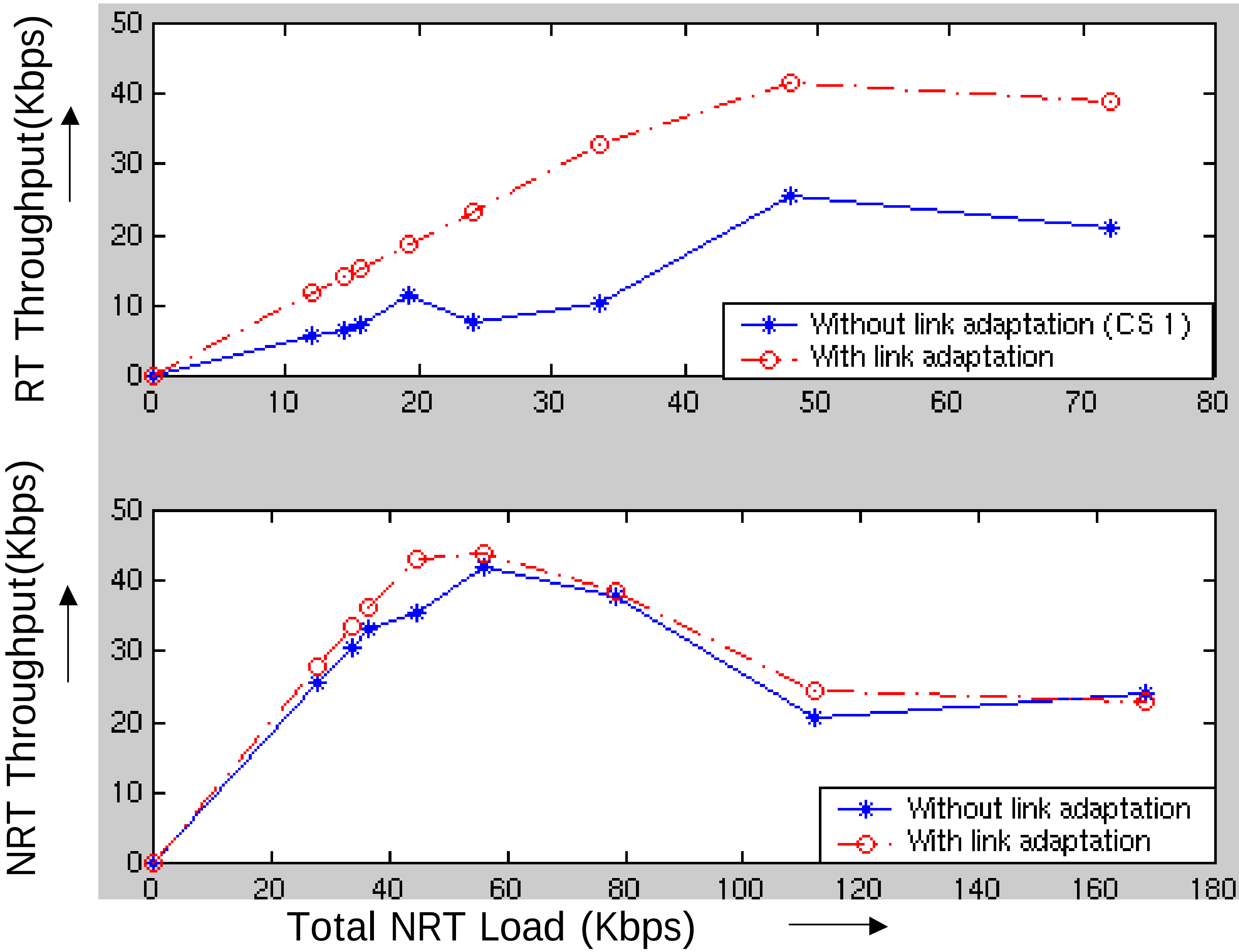
Total load per TS vs. total throughput per TS

10 MS (3 RT, 7 NRT), exp. distributed packet (mean 200 bytes)



Throughput vs. load

10 MS (3 RT, 7 NRT), exp. distributed packet (mean 200 bytes)



Blocking and dropping

- Packets can be lost in two ways:
  - Blocking
  - Dropping

Traffic	Blocking	Dropping
RT	<1%	0%
NRT	<1%	< 1%

Next Steps

- Get BLER vs. C/I curves for the 8 coding schemes of EDGE and study the link adaptation gains of EDGE vs. GPRS.
- Investigate throughput and delay gains for other traffic models like railway and web through link adaptation.